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6-10/95
ACID DEPOSITION IN THE BRIDGER WILDERNESS - FIRST YEAR RESULTS

AQRV Monitoring Report No. 1

by
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June 2, 1986
Bridger-Teton National Forest
Jackson, Wyoming

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ACID DEPOSITION IN THE BRIDGER WILDERNESS - FIRST YEAR RESULTS

Introduction

The Forest Service has established a wide ranging monitoring program in the Bridger and Fitzpatrick Wildernesses to measure any possible effects of air pollution originating from Wyoming, interstate, or international sources. This program was prompted by the discovery and development of the Riley Ridge natural gas field in western Wyoming. The Forest Service has prepared an Air Quality and Air Quality Related Values (AQRV) Monitoring Plan (1) to guide the collection of information relating to potential impacts due to air pollution in these wildernesses. The Clean Air Act of 1977 mandates the protection of air quality and related values in the designated Class 1 areas such as the Bridger and Fitzpatrick Wildernesses. This same Act confers upon the State of Wyoming the primary responsibility of enforcing the provisions of the Act. One of these provisions establishes a Prevention of Significant Deterioration (PSD) permit process for new industrial facilities. The State of Wyoming Air Quality Department administers the PSD program. Under PSD permit conditions issued to Exxon and Chevron Corporations for new refineries located in southwest Wyoming, both Exxon and Chevron Corporations were required to fund the installation and operation of two National Atmospheric Deposition Program (NADP) sites and four atmospheric deposition collection sites in the Bridger Wilderness. Exxon and Chevron Corporations requested the Forest Service to operate these sites which had been identified as monitoring needs in the previously referenced AQRV Monitoring Plan. The Bridger-Teton National Forest honored this request and has been operating these six sites since October, 1984.

The objectives of this atmospheric deposition monitoring program were as follows:

1. To determine if any significant changes in the deposition of the acidifying anions, with particular emphasis on sulfate, occurred at increasing elevation in the wildernesses. Increased deposition of sulfate and nitrate had been predicted by the Forest Service (2) at higher elevations due to the "orographic" effect. This prediction of orographic influence on atmospheric deposition of sulfate and nitrate was subsequently challenged (3). This is an important question since it is well established that the higher elevation alpine and subalpine zones of the wildernesses are more sensitive to acid deposition.

2. To discover whether or not a spatial deposition gradient exists among the NADP sites. It has been suggested that southwest Wyoming industries may be contributing to the acid deposition being experienced in the Bridger and Fitzpatrick Wildernesses to a large enough degree that an acid deposition gradient would occur increasing from northwest to southeast along the Wind River Range. This pattern could take place since the direction of airflow from the plant sites in southwest Wyoming is directed more to the southern end of the Wind River Mountains and the wildernesses contained therein.

3. To compare the results of precipitation chemistry collected by the NADP and the bulk collectors.

4. To compare the snow chemistry of samples taken from the bulk collector and side-by-side snow cores.

This report will evaluate the first year measurements in light of these objectives. This report is the first of what is anticipated to be a series of monitoring reports covering various aspects of the overall monitoring program.

Methods and Procedures

A more detailed presentation of the collection devices, measurement methods, frequency of sampling, and quality control procedures is contained in the study plan which is appended to this report. In general a strong emphasis is given to treating the NADP and bulk collector samples as nearly identical as possible. In that way comparison of results between the two precipitation collectors will be less subject to errors associated with sampling procedure. For this reason an agreement has been made with the Central Analytical Lab of the National Atmospheric Deposition Program to process water samples from both types of collectors for chemical analysis. For this first year it was necessary to have the NADP samples processed by their Central Analytical Lab and the bulk deposition samples analyzed by the National Water Quality Lab of the U. S. Geological Survey. Both labs use comparable analytical methods and cooperate in cross laboratory quality control audits. Nevertheless, the practice of having one lab analyze both sets of samples by the same technicians with a common quality assurance protocol should improve the accuracy of the comparison in future years.

Results

A tabular summary of the chemical constituents of major interest for each site is given in the appendix. It will be noticed that the measurements are incomplete for certain locations due to instrument malfunction, adverse weather conditions, or technician error. These first year difficulties should be behind us, and we expect a considerable improvement for the remainder of this initial three year period. For individual sites the precipitation amount, sulfate and nitrate concentrations and deposition, and the hydrogen ion concentration is shown for the period of measurement. The precipitation amounts were obtained from snow core transect measurements and the Hubbard Brook collectors. Preliminary comparisons between the snow collectors and the snow core transects indicate the snow collectors undercatch by as much as 50% in some locations. In future years we will have a more complete comparison between the two. It will also be possible to compare the Hubbard Brook collectors with the NADP standard rain gauge at the three sites where those instruments are colocated. This comparison will allow us to improve the prediction of rainfall for the Hubbard Brook collectors at the wilderness sites. In like fashion the comparison of snow core transects and the NADP wet bucket will permit an evaluation of the catch efficiency of the wet buckets.

Orographic Influence - The question of whether or not the deposition of sulfates increased with elevation during this past year can be answered by referring to the deposition and concentration tables in the appendix. These tables show that for a time period of 309 days the Black Joe site at an elevation of 10,256 ft. had a sulfate deposition total of 11.86 Kg/HA. When this total is compared to the annual sulfate deposition of 1.91 Kg/HA at the Pinedale NADP site, elevation approximately 7,800 ft., it becomes quite apparent that the higher elevations in the wilderness are receiving considerably more deposition. This same pattern of higher deposition at the higher elevation is also born out by the results from Hobbs Lake for 311 days of 7.9 Kg/HA at an elevation of 10,069 ft. The difference between Hobbs and Black Joe is explained by the greater amount of precipitation at Black Joe, 85cm and 137cm respectively. The Indian Park result is not directly comparable since the period of record is primarily the winter season, which as will be demonstrated later, has markedly lower deposition of sulfate than the spring-summer-fall season.

The explanation for the increased sulfate deposition with elevation becomes apparent when the sulfate concentrations for the different sites are examined. Comparing the same monitoring stations we find the sulfate concentrations in order of increasing elevation to be as shown on the table below.

	Pinedale (7800)	Hobbs Lake (10069)	Black Joe (10256)
Sulfate Conc.- ueq/l	18.9	19.3	18.0

These concentrations (precipitation volume weighted averages) represent nearly a full year's measurement and are not statistically different. It appears, therefore, that the original hypothesis of predicting sulfate deposition on the basis of orographic effect upon precipitation (2) is supported by the first year's results from the bulk deposition sites. Lester Pass is the highest elevation site, just under 11,000 ft., but not enough measurements were available to represent an annual concentration. The same is true for the Indian Park site at approximately 9,000 ft. Barring unforeseen difficulties, next year's results should produce sulfate concentrations along the entire elevational gradient.

Spatial Distribution of Sulfate Concentration - To assess the possibility of higher sulfate concentrations toward the southern end of the Wind River Mountains due to the influence of southwest Wyoming industrial sources, an analysis was made of sulfate concentrations for the Gypsum Creek, Pinedale, and South Pass NADP sites. Measurements were not available for all three sites for a full year so a six month period was selected when measurements were made for all three. This period was April 30, 1985 to Oct. 29, 1985. Gypsum Creek is near the northwest end of the Wind River Range; Pinedale midlocation, and South Pass at the southern end of the Range.

The concentrations are volume weighted averages for this time period and are given in the following table.

	<u>Gypsum Cr.</u>	<u>Pinedale</u>	<u>South Pass</u>
Sulfate Conc. - ueq/l	19.7	17.4	19.4

These six month averages were statistically tested and as might be expected no significant difference existed among or between any of the three. It would be more meaningful to look at least at a full year's comparison before any firm conclusion can be reached and two or three year's results would be even more desirable.

Other Objectives - Not enough data has been compiled to permit an evaluation of the objectives of comparing the chemistry of the NADP wet bucket samples and those of the bulk snow and rain collectors or of the bulk snow and snow cores. Analysis of these objectives should be possible in the next annual report.

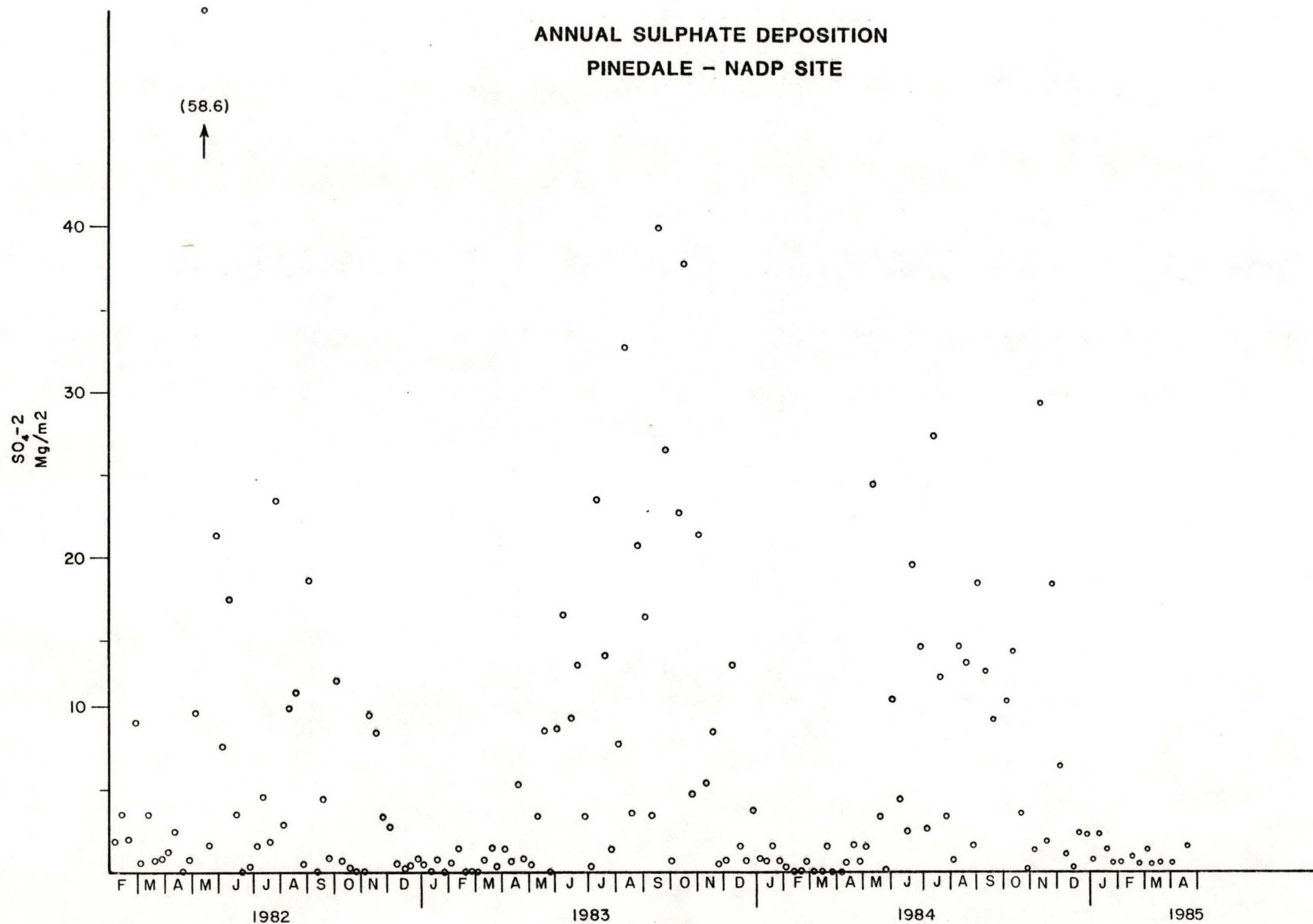
Seasonal Distribution of Sulfate Deposition - The NADP site at Pinedale has been in continuous operation since 1982. This period of record has been sufficient to reveal an interesting seasonal pattern to the deposition of sulfate. This pattern is shown on the accompanying graph for a three year period from 1982 through 1985. As can be seen unmistakably in this graph, the spring-summer-fall period shows a striking increase in the amount of sulfate deposition as compared to the mid-winter period. June through September appears to be the time of maximum deposition as contrasted to December through March when the minimum occurs. There are at least three possible explanations for this pattern, and a combined effect of all three is quite probable.

1. The winter period is a time in which the mesoscale pattern of circulation regulating the storm track shifts to the northwest rather than from the spring-summer-fall direction which is primarily out of the southwest. Commonly the winter storms originate in the gulf of Alaska and move into the upper Green River Basin from off the Washington and Oregon coast. This would imply a generally "cleaner" source area of air pollutants than the southwest storm track. In the spring-summer-fall more of the air masses come up from the southern California region and cross a greater number of pollution areas enroute to the upper Green River Basin.

2. The difference in cloud level air temperature between winter and summer is considerable and may be sufficient to cause a significant decrease in the photochemical transformation of SO₂ to SO₄.

3. As mentioned above there is little doubt that the NADP wet buckets are undercatching the actual snowfall. To a lesser extent the same is probably true for the standard rain gauge. So even though the sulfate concentrations are lower in the winter, the actual deposition is believed to be higher than

ANNUAL SULPHATE DEPOSITION
PINEDALE - NADP SITE



shown in the graph due to the inefficiency of the wet bucket and the rain gauge. And it should be mentioned that the results shown on the graph are based on the preliminary lab analyses which may represent the wet bucket volumes only. At any rate there is no question that the winter deposition is considerably reduced below the summer levels despite the gauging inefficiency.

In future years it will be possible to discover whether this same seasonal pattern occurs at the other NADP sites, which is likely to be the case.

Conclusion

As might be expected these first year results did not answer all the questions which prompted the bulk deposition and NADP network. Nevertheless, the measurements which were made provided a solid foundation for establishing workable field and laboratory procedures. These procedures and subsequent analysis of results should give reasonably definitive conclusions over the next two years. At the end of this time it will be possible to assess the need to continue on with the study at the same or a reduced level of effort.

The primary finding of the first year results is the confirmation of the orographic effect upon sulfate deposition in the wildernesses. This finding is important as it relates to the overall question of threshold levels of atmospheric deposition in relation to acidification of surface waters in the wildernesses. The conclusion that the deposition of the principal acidifying anion, sulfate, is greater in that portion of the alpine ecosystem which is most susceptible to acidification is supported by the first year results of this study.

Acknowledgments

The author wishes to express his strong appreciation to the many professionals who carried out the measurements in the Wind River Mountains under conditions which would make the postman's motto seem like a kindergarten exercise by comparison. In particular Bo Stuart, Dean Grover, Skip Shoutis, Marty Vidak, and Bill Gabbert of the Forest Service and Steve Laster of the Bureau of Land Management made heroic efforts on many occasions which insured high quality and consistent data, when it would have been much more comfortable and less risky to turn around and try again another day.

REFERENCES

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3. Hidy, G., 1985. Acidic deposition in Wyoming - A technical summary and prospective. Report - Desert Research Institute

APPENDICES

1. Study Plan - Bulk Deposition Collectors, AQRV Monitoring Bridger & Fitzpatrick Wildernesses
2. Summary Tables of Measurements from Bulk Collector Sites

MAY 27, 1986
STUDY PLAN - BULK DEPOSITION COLLECTORS
AQRV MONITORING BRIDGER & FITZPATRICK WILDERNESSES

Introduction

The discovery of a natural gas field, reported to be one of the largest in the world, in western Wyoming near the town of Big Piney has created the need for this study. The natural gas field, called the Riley Ridge Project, is being developed initially by Exxon corporation with the potential of other major energy corporations joining in at a later date (1). The refining of this natural gas produces SO₂ as an emission even with the very efficient emission control technology which has been proposed. In addition to emissions from the Riley Ridge Project a phosphate plant being built by Chevron Chemical corporation near Rock Springs will also produce SO₂ emissions. Due to the acid precipitation potential associated with these and other industrial sources of SO₂ and NO_x emissions in southwest Wyoming, the Forest Service has undertaken a monitoring program in the downwind Wind River Mountains which contain the Bridger, Fitzpatrick and Popo Agie Wildernesses (2). These Wildernesses contain approximately 2000 lakes with over 700 of these lakes sustaining a trout fishery.

The results from an NADP station, Pinedale, located close to the Bridger Wilderness has shown that acid deposition is currently taking place, prior to the addition of the Exxon and Chevron plants. The probable sources of this acid deposition, other than natural sources, appear to be the existing trona, natural gas, and coal-fueled power plants in southwest Wyoming, along with longer distance sources from the Salt Lake City metropolitan area, the copper smelter complex in southern Arizona and New Mexico, and the Los Angeles basin (3).

Because of the threat to the Wilderness alpine lakes posed by acid deposition the State of Wyoming Air Quality Division has required Exxon and Chevron corporations to underwrite the expense of acid deposition collection facilities in and near the Bridger Wilderness. This study plan will govern the operation of these acid deposition sites.

Location, Description and Instrumentation of Collection Sites

Two NADP sites outside the Wilderness boundary and four bulk sites within the Bridger Wilderness make up the deposition monitoring network set up under conditions attached to the State of Wyoming Prevention of Significant Deterioration permits issued to Exxon and Chevron. The previously mentioned Pinedale NADP site is in addition to these as is another NADP site near Lander, Wyoming. Both of these NADP sites are administered by the Bureau of Land Management.

The NADP sites funded by Exxon and Chevron are located at Gypsum Creek in the upper Green River valley toward the northern end of the Wilderness and near South Pass toward the southern end of the Wilderness. Three of the bulk

collection sites are located in the Fremont Lake watershed portion of the Wilderness near Pinedale, Wyoming. These three are designated Indian Park, Hobbs Lake, and Lester Pass. The other bulk collector is in the Big Sandy watershed portion of the Wilderness at a site called Black Joe.

The NADP sites are equipped with the standard wet and dry instrumentation prescribed in the NADP protocol. In addition at the Gypsum Cr., Pinedale and South Pass NADP sites bulk collection samplers have been installed. These bulk samplers are a winter snow collector and a summer rainfall collector. The snow collector consists of an 18 inch diameter metal tube which supports a plastic bag into which the snow is deposited. The rain collector is unofficially termed a **Hubbard Brook** collector and consists of a plastic funnel attached by tubing looped once to a plastic bottle.

Laboratory Analysis

Because the chemical analyses of the bulk and NADP collectors will be compared and evaluated, it was decided to have both sets of precipitation samples analyzed at the same laboratory to reduce the possibility of lab error affecting the results. For that reason the bulk samples will be processed by the NADP Central Analytical Laboratory (CAL) in the same manner as an NADP sample - even to the extent of using the same analysts when possible. The same suite of chemical analyses will be made on the bulk samples as are made on the NADP samples and the same QA/QC procedures followed by CAL will apply to both.

Study Objectives and Design

One of the main questions to be answered by the atmospheric deposition sampling is whether acid deposition changes with elevation. The hypothesized orographic effect is of great concern to the Forest Service, the State of Wyoming, and the energy industry. To address this question the Indian Park, Hobbs Lake, and Lester Pass sites were chosen in a sequence from the Pindale site to span an elevation range from approximately 7600 to 11,000 feet within the same general vicinity. The concentrations observed in the bulk samples will indicate if an increase in deposition has occurred with an increase in elevation since the precipitation is known to increase at higher elevation. The orographic effect on acid deposition in turn relates to the assessment of risk of acidifying the higher elevation Wilderness lakes. Comparisons can be made to wet deposition rates from areas of the world where surface water acidification has occurred (4).

The spatial distribution of atmospheric deposition is also of interest. If local southwest Wyoming industry is contributing a significant amount of the acid deposition currently being measured, then there may be a deposition gradient increasing toward the south end of the Wind River Mountains and the Wildernesses.

Another objective of the study is the comparison of the bulk precipitation samples with the wet only NADP sample. This comparison should allow an estimation of the significance of dry particulate deposition in the

bulk collectors.

A further objective is to compare the chemical analyses of the bulk snow collector to snow cores taken at the same location. Should the snow cores prove to be closely enough correlated to the bulk snow chemistry, it would be possible to rely on snow core results for future monitoring.

The overall design of the study is relatively simple. As discussed above bulk collectors are distributed along an elevation gradient. Three of the NADP sites are located at the north, middle and south end of the Wind River Mountains. The fourth NADP site is located on the eastern side of the continental divide. Bulk snow and rain collectors are colocated at the Gypsum Cr., Pinedale, and South Pass NADP sites. Two Hubbard Brook collectors are installed at each of the colocations to improve the opportunity of collecting a relatively uncontaminated sample.

Sampling Procedures and Frequency

Samples from the bulk snow collectors are taken at approximately two month intervals during the winter. The plastic bag containing the snow is transported from the Wilderness location on a ski sled and later snow machine to the cooperative Forest Service/Bureau of Land Management field lab in Pinedale. There the snow sample is weighed for volume determination and allowed to melt. When melting is complete, a sample is taken for pH and conductivity measurement using deionized washed containers. Another sample is transferred to the shipping bottle supplied by CAL. These shipping bottles have been deionized washed and sealed by CAL. The bottle is then refrigerated and sent to CAL within a week. In so far as is possible the bulk snow and rain samples are handled in the field similarly to the NADP samples. Snow core samples will be taken at the time the bulk snow is collected. The snow cores are collected with the SCS snow core equipment. First a snow core transect will be run to determine the amount of water in the snow pack. Then using the snow core tube, snow cores sufficient to nearly fill one of the 1 gal. bottles will be poured directly into the sample bottle - only full cores will be used in making the snow core sample. At the field lab the snow core sample will be treated the same as a bulk snow sample except it will not be necessary to weigh the sample bottle.

The rain samples will be transported in the collector bottle from the Hubbard Brook collector to the FS/BLM lab. A new collector bottle(s) will be installed. As there are two HB collectors at each site the sample water from both will be composited in one sample if both HBs are "clean" and a regular or split sample is scheduled. Otherwise, the cleaner HB will be used for the sample. At the FS/BLM lab an amount sufficient to make the pH and conductivity measurement will be poured off after the collector bottle has been weighed. The water will be transferred from the collector bottle to a CAL shipping bottle. The bottle will be sent to CAL in the NADP shipping container if the sample is from a HB colocated with the NADP equipment. If the sample is from a Wilderness site, the shipping bottle will be refrigerated and shipped with other Wilderness site samples within a week. Should no rainfall have occurred at the three NADP sites where Hubbard Brook (HB) samplers are colocated, then one of the HB collectors will be selected for a blank sample.

The blank will be made by pouring the 120 ml of deionized water supplied by CAL down through the funnel of the HB and into the collection bottle. The collection bottle will be taken to the field lab and after two days the blank sample water poured back into the original CAL bottle in which the deionized water was shipped. From that point the blank sample will be handled as per the procedure described above. The minimum amount of rainwater in an HB which will constitute a valid sample is 35 ml. for a Wilderness site. If there is any doubt at the site whether or not the minimum amount has been collected, the technician will composite the rainfall from the two HB and then take a blank sample also, bringing back the two samples to the field lab where weighing will determine if the minimum has been collected. For the HB sites in the Wilderness unless a blank sample is called for in the schedule, the HB collector bottles will be left in place until rainfall has occurred. For an NADP colocated HB collector so long as a visible amount of rainfall can be seen in the collector bottle and can be poured into a shipping bottle that sample will be sent to CAL similar to the procedure for an NADP sample. No attempt will be made to take pH or conductivity at the FS/BLM field lab of a sample which is less than 70 ml.

Quality Assurance - Quality Control

An overall Quality Assurance/Quality Control Plan has been prepared for the Air Quality Related Values Monitoring Plan for the Bridger and Fitzpatrick Wildernesses. Those sections of the QA/QC Plan which pertain to the operation of the NADP and bulk collection sites will be applied. At the CAL the quality assurance/quality control procedures developed for the NADP program will be applied to the bulk samples as well. To verify the accuracy of both the field and laboratory procedures a system of duplicate, split, and blank samples will be employed. Duplicate samples will be made by treating the contents of each HB collector at the same site as separate samples. In the case of snow core samples two sets of snow cores will be collected and each handled as a separate sample. It will not be possible to take duplicate samples of the bulk snow as there is only one bulk snow collector at each site. Split samples will be prepared by dividing the melt water in the case of snow or rainwater into roughly equal amounts at the field lab and shipping each as a separate sample to CAL. The procedure for blank samples for the HB has been described above. For the bulk snow samples an empty collection bag will be rinsed in the deionized water, allowed to sit for two days, and then poured out and otherwise treated as a regular sample. The following table summarizes the number of samples to be collected annually.

<u>Site</u>	<u>SAMPLE TYPES</u>			
	<u>Regular</u>	<u>Duplicate</u>	<u>Split</u>	<u>Blank</u>
NADP Locations (3)				
- Bulk Snow	3	N/A	1	1
- Hubbard Brook	18	3	3	*

Wilderness Locations (4)

- Bulk Snow	3	N/A	1	1
- Hubbard Brook	10	3	3	2
- Snow Cores	3	1	1	N/A

* Some of the regular samples will be blanks if rainfall has not occurred in that week interval. A minimum of 3 blanks will be required for each HB location and if not satisfied within the 18 regular samples, then additional blanks will be prepared. This schedule will result in 118 regular, 25 duplicate, 32 split, and 24 blank samples on an annual basis. Except as noted in * above it is unlikely that these totals will be exceeded and should be considered the probable maximum number in any year.

Analysis of Results

The data resulting from this study will be shared freely between the CAL and the Bridger-Teton National Forest. This data will also be available to Exxon and Chevron Corporations and the State of Wyoming Air Quality Division. Joint evaluation and reporting of results by CAL and the Bridger-Teton National Forest is anticipated.

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1984-85 WIND RIVER ACID DEPOSITION DATA SUMMARY

Sulfate and Nitrate Deposition

<u>Location</u>	<u>Deposition</u> Kg/HA		<u>Time Period</u>	<u># of Days</u>
	<u>SO4</u>	<u>NO3</u>		
Black Joe	11.86	2.98	11/06/84-09/11/85	309
Hobbs	7.90	2.12	10/23/84-08/30/85	311
Gypsum Ck.	2.12	0.39	11/20/84-09/10/85	294
Indian Pk.	2.31	0.77	10/17/84-06/28/85	254
Lester Pass	0.44	0.089	10/23/84-02/06/85	106
	0.63	0.18	07/01/85-08/30/85	61

Average Concentrations of Sulfates and Nitrates

<u>Location</u>	<u>Avg. Concentration</u> (ueq/l)		<u>Time Period</u>	<u># of Days</u>
	<u>SO4</u>	<u>NO3</u>		
Black Joe	18.01	3.52	11/06/84-09/11/85	309
Hobbs	19.26	4.01	10/23/84-08/30/85	311
Gypsum Ck.	23.00	3.23	11/20/84-09/10/85	294
Indian Pk.	10.68	2.74	10/17/84-06/28/85	254
Lester Pass	13.53	2.10	10/23/84-02/06/85	106
	26.52	5.63	07/01/85-08/30/85	61

1984-85 WIND RIVER BULK DEPOSITION DATA

Black Joe Deposition Data

Date	PPT (cm)	SO4 (mg/l)	SO4 (Kg/HA)	NO3 (mg/l)	NO3 (Kg/HA)	[H+] (eq/l)
02/21/85	47.89SC	0.49	2.35	0.13	0.623	1.26 * 10 ⁻⁷
06/28/85	81.15SC	0.98	7.95	0.23	1.87	5.01 * 10 ⁻⁸
07/25/85	2.11EST	1.85	0.390	0.58	0.122	1.60 * 10 ⁻⁵
08/04/85	1.65EST	1.6	0.264	0.48	0.079	3.16 * 10 ⁻⁵
09/11/85	4.29EST	2.1	0.901	0.68	0.292	3.16 * 10 ⁻⁷
TOTALS#	137.09		11.86		2.98	

Hobbs Deposition Data

Date	PPT (cm)	SO4 (mg/l)	SO4 (Kg/HA)	NO3 (mg/l)	NO3 (Kg/HA)	[H+] (eq/l)
02/08/85	33.78SC	0.30	1.013	0.10	0.338	2.51 * 10 ⁻⁷
04/12/85	17.78SC	0.74	1.316	0.22	0.391	7.94 * 10 ⁻⁷
06/12/85	24.64SC	1.8	4.435	0.41	1.01	3.76 * 10 ⁻⁷
07/01/85	3.07EST	0.55	0.167	0.10	0.0307	1.04 * 10 ⁻⁵
07/19/85	1.78EST	2.2	0.391	0.66	0.117	6.31 * 10 ⁻⁶
07/28/85	1.35EST	1.1	0.148	0.62	0.083	3.98 * 10 ⁻⁵
08/02/85	1.65EST	0.98	0.162	0.27	0.045	1.26 * 10 ⁻⁵
08/30/85	1.35EST	2.0	0.269	0.79	0.106	7.94 * 10 ⁻⁶
TOTALS#	85.39		7.901		2.12	

Gypsum Ck. Deposition Data

Date	PPT (cm)	SO4 (mg/l)	SO4 (Kg/HA)	NO3 (mg/l)	NO3 (Kg/HA)	[H+] (eq/l)
05/14/85	6.12BS	1.7	1.041	0.31	0.190	1.26 * 10 ⁻⁷
06/28/85	5.26HB	0.82	0.431	0.06	0.032	1.00 * 10 ⁻⁶
07/16/85	1.78HB	0.48	0.0853	0.01	0.001	6.31 * 10 ⁻⁶
07/23/85	0.33HB	2.0	0.0660	0.23	0.008	1.58 * 10 ⁻⁶
07/30/85	1.65RG	0.82	0.135	0.25	0.041	5.01 * 10 ⁻⁶
08/06/85	0.76HB	1.6	0.122	0.61	0.046	2.51 * 10 ⁻⁶
08/27/85	0.36RG	1.5	0.053	0.57	0.020	3.16 * 10 ⁻⁶
09/10/85	3.18HB	0.67	0.213	0.16	0.051	1.00 * 10 ⁻⁷
TOTALS#	19.43		2.12		0.389	

Indian Pk. Deposition Data

Date	PPT (cm)	SO4 (mg/l)	SO4 (Kg/HA)	NO3 (mg/l)	NO3 (Kg/HA)	[H+] (eq/l)
01/24/85	21.46SC	0.39	0.837	0.12	0.258	2.00 * 10 ⁻⁷
04/14/85	16.41SC	0.60	0.985	0.20	0.328	1.58 * 10 ⁻⁷
06/28/85	7.16EST	0.68	0.487	0.25	0.175	2.51 * 10 ⁻⁶
TOTALS#	45.03		2.309		0.765	

Lester Pass Deposition Data

Date	PPT (cm)	SO4 (mg/l)	SO4 (Kg/HA)	NO3 (mg/l)	NO3 (Kg/HA)	[H+] (eq/l)
02/06/85	6.81BS	0.65	0.443	0.13	0.089	3.98 * 10 ⁻⁷
02/07/85-07/01/85	NO DATA					
08/01/85	2.46HB	0.86	0.212	0.27	0.066	1.58 * 10 ⁻⁵
08/30/85	1.12HB	3.7	0.414	0.98	0.110	7.94 * 10 ⁻⁷
TOTALS#	10.39		1.069		0.265	

SC: PPT depth obtained from snow core sample (other data within row from bulk snow).

EST: PPT depth estimated (other data within row from Hubbard Brook collector).

HB: All data within row obtained from Hubbard Brook collector.

BS: All data within row obtained from bulk snow collector.

RG: PPT depth obtained from NADP rain gage (other data within row from Hubbard Brook collector).

#Due to rounding error the data may not sum to the totals presented.